(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 641 689 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number : 94306454.3

(51) Int. Cl.[6] : B60R 21/00

(22) Date of filing : 01.09.94

(30) Priority : 03.09.93 US 116929

(43) Date of publication of application :
08.03.95 Bulletin 95/10

(84) Designated Contracting States :
DE FR GB IT

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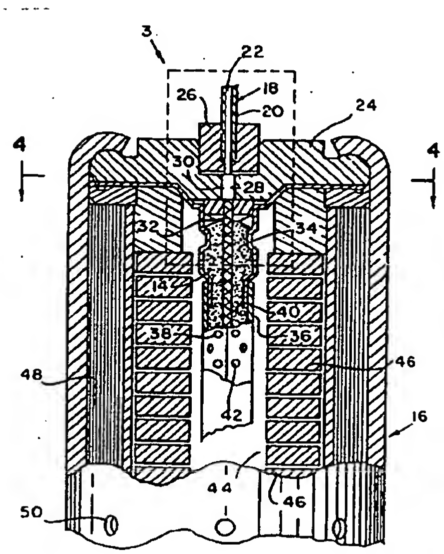
(54) Direct laser ignition for gas generating material.

(57) A device is provided for ignition of a pyrotechnic or hybrid inflator (16) for use in motor vehicles by the input of energy provided by a laser source. The laser energy is conducted through an optical fibre (18) and an optical window (28) in the inflator housing (16) where the ignition of a propellant initiator (14) is triggered. This apparatus eliminates the potential for ignition of the inflator by radio frequency energy or static electricity acting on the electrical squib which- is standardly used to ignite an inflator. This design further simplifies the igniter assembly for use in an inflator.

FIG. 2



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BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to gas generators for inflating vehicle inflatable restraint cushions, commonly known as an air bag restraint systems, so as to provide impact protection to occupants of the vehicles. More particularly, this invention relates to an improved apparatus for the ignition of gas generating material within the inflator.

Description of Related Art

The part of an air bag restraint system for use in the passenger compartment of a vehicle, referred to as an air bag module, typically includes a canister, which encloses a gas generator, or as it is commonly known an inflator, and at least part of an air bag, and a cover which conceals the air bag module from view. When the vehicle is involved in a collision, a crash signal initiates operation of the inflator to cause the air bag to deploy. The inflator produces an inert gas (e.g., nitrogen) which is directed under pressure into the air bag to force the air bag out of the canister incorporated in the module and into the passenger compartment of the vehicle. In a pyrotechnic type, inflator gas is produced by the burning of a gas generating material. As the air bag is forced out of the container, pressure exerted on the cover causes selected portions of the cover to separate in a predetermined manner along tear seams to enable the air bag to be directed into the passenger compartment. As the air bag is directed into the passenger compartment, it is inflated by the continued flow of gas produced by the inflator.

The gas generator for a passenger vehicle includes a disk-shaped or a cylindrical housing having openings therein for release of gas. A gas generating material is deployed in the interior of the housing in pellet or wafer form. A cooling and filtering structure surrounds the combustible gas generating material charge in order to filter out hot or burning particles and cool the gas produced by the gas generating material. Ignition of the gas generating material is achieved by an igniter tube extending through the gas generating material along the axis of the charge and the housing. The tube typically contains a rapid detonation or deflagration cord, or fuse, and igniter powder. An electric initiator and charge, or squib, is mounted to the housing and lights the rapid deflagration cord. The rapid deflagration cord in turn sets off the igniter powder, which bursts the igniter tube and lights the gas generating material.

Typically, the energizing terminals of electric squibs are connected by parallel rod conductors to the interior of a container or cup containing a pyrotechnic material. In another form, a coaxial type, one of the conductors is tubular in form and the other conductor is a rod centrally positioned therein. The ends of the conductors in the container, in both types of electric squibs, are joined together by a resistance wire or bridge that is designed to rapidly heat the pyrotechnic material to its ignition temperature when energized with sufficient electrical current.

A long standing problem with electric squibs is that their energizing terminals tend to function as antennas that pick up extraneous radio-frequency and electro-static energy. Radar signals are of particular concern because of their tendency to form transitory peaks of high intensity that are capable of firing the squib. Such firing is caused either by heating the pyrotechnic material of the squib to its flame temperature by way of a contiguous, metallic part, or by corona discharge or sparking into the pyrotechnic material.

A solution to the problem has been proposed by Holmes, U.S. Patent No. 4,306,499, which patent is assigned to the assignee of the present invention. Holmes discloses a pair of normally ungrounded terminals surrounded by a chamber holding ferrite beads. The ferrite beads are in thermal contact with the grounded chamber walls. The ferrite beads dissipate radio-frequency electrical energy and the heat generated thereby is conducted to the grounded walls and into a heat sink. This arrangement does not provide adequate dissipation of radio-frequency during prolonged or high energy outbursts. Further, the overall design and assembly of the inflator could be drastically simplified by the elimination of an electrically energized squib. Therefore, it is preferable to eliminate electrical initiation of an air bag inflator through conductive wires such as is used in a squib.

Lewis et al., U.S. Patent No. 3,408,937, discloses the use of laser radiation to detonate multiple explosive devices for use in space craft. The intense radiation produced by the laser is conducted through multiple light conductors to the multiple explosive devices. The explosive devices are used to provide for the rapid separation or deployment of equipment and safety devices within the space craft.

SUMMARY OF THE INVENTION

An object of this invention is to eliminate the potential of accidental ignition of an automotive air bag inflator due to the effect of radar and other sources of extraneous radio-frequency on an unshielded or ungrounded squib.

Another object of this invention is to eliminate the potential of accidental ignition of an automotive air bag inflator due to the effect of the build-up of electrostatic energy on an unshielded or ungrounded squib.

Another object of this invention is to provide a simplified ignition chain for initiating the gas generating process within an air bag inflator.

These and other objectives of the invention,

which will become apparent from the following description, have been achieved by a novel ignition device for use with a gas generator for use in motor vehicles comprising, a laser source to supply radiant energy, an optical conductor to carry the radiant energy from the laser source, and an automotive air bag gas generator provided with an optical window to conduct the radiant energy from the optical conductor to a propellant initiator means which in turn ignites the gas generating material inside the gas generator.

The optical conductor, for use with this invention, is typically an optical fiber. The gas generator, or as it is more commonly known an inflator, comprises a hollow open-ended housing which contains a propellant initiator means, a gas generating material, and means to filter and cool the generated gas. Apertures in the walls of the inflator permit generated gases to flow from the inflator to an automotive air bag cushion. A novel end cap, having an aperture into which is sealed an optical window, caps the inflator to form a sealed combustion chamber. The optical window conducts radiation carried by the optical fiber to the propellant initiator means. Optical contact must be provided between the optical fiber, the optical window, and the propellant initiator means.

The device of this invention can be used with the elongated cylindrical housings used for passenger side inflators, the disk-shaped circular housing typically used for driver side inflators, a hybrid inflator or any inflator which normally uses an electrical squib to initiate the burning of a gas generating material.

The propellant initiator means can be any initiator known in the art. When a passenger side inflator is used, a linear deflagration cord is used as the propellant initiator means. To ensure proper optical contact between one end of the linear deflagration cord and the optical window a collet having a central aperture is inserted over one end of the linear deflagration cord. The linear deflagration cord can be threaded into the collet to ensure that the linear deflagration cord will not move from the optical window. The collet and in turn the linear deflagration cord are then held into position by a support means which is in close proximity to the optical window. A spring means may be inserted between the collet and the support means thereby improving the optical contact between the end of the linear deflagration cord and the optical window.

BRIEF DESCRIPTION OF THE DRAWINGS

With this description of the invention, a detailed description follows with reference being made to the accompanying figures of drawings which form part of the specification, in which like parts are designated by the same reference numbers, and of which:

Fig. 1 is a diagrammatical view illustrating the components comprising the ignition system of the invention;

Fig. 2 is a cross-sectional view illustrating a gas generator with attached optical fiber for conducting radiant energy from the laser;

Fig. 3 is an enlargement of section 3 of Fig. 2;

Fig. 4 is a cross-sectional view taken along line 4-4 of Fig. 2 illustrating the arrangement of the ignition system;

Fig. 5 is a cross-sectional view illustrating the laser ignition system of this invention installed into a driver side inflator; and

Fig. 6 is a cross-sectional view illustrating the laser ignition system of this invention installed into a hybrid inflator.

DETAILED DESCRIPTION OF THE INVENTION

Description of the Preferred Embodiments

Fig. 1, diagrammatically shows an inflator ignition system of this invention, with a DERM 10 (Diagnostic Energy Reserve Module) (shown herein as a black box), which contains diagnostics for analyzing the input from sensors (not shown), electrical switches and associated equipment, a power supply, and a laser source **12** which emits a coherent light beam of the appropriate frequency to ignite the propellant initiator means **14** (shown in Fig. 2). The laser source **12** is coupled to an inflator **16** via optical fibre cable **18** comprising an external coating **20** and an optical fibre or optical fibre bundle **22** (shown in Fig. 2). The optical fibre bundle **22** may comprise one or more optical fibres. Herein, for the sake of simplifying the drawings a single optical fibre **22** is shown as the bundle. Further, herein, for the purpose of simplicity a single laser source **12** connected to a single inflator **16** is shown. However, multiple laser sources **12** may be used to provide a back-up ignition source should one laser source **12** be damaged. In addition, a single laser source **12** may be used, by means of an appropriate coupling and switching network, to ignite more than one inflator **16**.

The inflator **16** of this invention is shown in side cross-sectional view in Fig. 2 and in detail in Fig. 3. The optical fibre cable **18** conveying radiation is attached to an end cap **24** of inflator **16** by connector **26**. The optical connector **26** is optically coupled to an optical window **28**. "Optically coupled" or "coupled optically" herein means that a first object is aligned with a second object such that radiation may be conducted from the first object to the second object without a significant loss in the amplitude of the radiation. "Optically coupled" or "coupled optically" does not require physical contact between the first object and the second object. The optical window **28** is sealed in a first aperture **30** formed in end cap **24**. The optical window **28** is transparent at the frequency of light used to initiate the inflator **16**. The optical window **28**

is optically coupled with a propellant initiator means or igniter shown generally at **14**. The arrangement of the aforementioned elements is shown in a top cross-sectional view in Fig. 4 to clarify the interrelation of the components.

To ensure that the inflator remains sealed during operation so that generated gases follow the intended path, the optical window **28** must be hermetically sealed into the inflator end cap **24**. This can be achieved by fixing a glass chip in aperture **30** and heating the end cap **24** to expand the metal from which the end cap **24** is made. Through a series of heating steps the glass is melted so that the molten glass flows and fuses with the walls of the aperture. As the end cap **24** is cooled, the glass solidifies and bonds with the metal thereby forming a gas tight seal. Also, as the metal of the end cap **24** contracts the optical window **28** is compression sealed into the first aperture **30** thus further ensuring a gas tight seal.

The igniter **14** normally comprises an RDC **32** (Rapid Deflagration Cord) located generally in the center of the igniter **14**. The RDC **32** is surrounded by igniter material **34**, which is a mechanical mixture of boron and potassium nitrate ($BKNO_3$), typically 25% boron and 75% potassium nitrate. The igniter material **34** is held in an igniter housing **36** by a thin layer of barrier foil **38** which is attached to the inside surface **40** of the igniter housing **36**. Upon ignition of igniter material **34**, hot ignition gases build pressure within the igniter **14**, rupturing the barrier foil **38** and emerging from the igniter housing **36** through apertures **42**, initiating the burning of the gas generating material **44**. The gas generating material **44** is shown here as wafers **46**, which are typically used in passenger side inflators **16**. Gas generated by the gas generating material **44** is filtered and cooled by a filter pack **48** and exits the inflator through inflator apertures **50**.

To ensure optical coupling between the optical window **28** and the ignition end **52** of the RDC **32**, the RDC **32** can be attached to a collet **54**, by appropriate means such as threading the RDC **32** into collet **54**. The collet **54** is held in place adjacent to the interior surface **56** of end cap **24** by a retainer **58** attached to the igniter housing **36**. Springs **60** inserted between retainer platform **62** and the base **64** of the collet **54** press the ignition end **52** of the RDC **32** against the inner surface **66** of optical window **28**. The RDC **32** passes through aperture **68** formed by the retainer **58**. However, an optional gap **69** may be provided between the ignition end **52** of the RDC **32** an the inner surface **66** of the optical window **28**. Where a gap **69** is provided, the RDC **32** must still be optically coupled with the optical window **28**.

The operation of this invention with a driver side module is illustrated in Fig. 5, wherein a driver side inflator is shown generally at **70**. Where like components to those used in the passenger side inflator **16** are used the same reference number is also used. The optical fibre cable **18** conducting radiation from the laser source **12** is attached to the base plate **72** of the driver side inflator **70** by connector **26**. The optical fibre **22** is optically coupled to the optical window **28** sealed in first aperture **74** in the base plate **72** of driver side inflator **70**. The inner surface **66** of the optical window **28** is optically coupled to igniter **14**. Upon ignition, igniter **14** generates high temperature gases which rupture barrier foil **76** on the inside surface **78** of the ignition chamber **80**. The hot gases are conveyed through aperture **82** into the gas generator chamber **84** where the gas generating material **44** is ignited. Generated gas passes through filter pack **48** and exits through apertures **86** formed in the outer wall **88** of the driver side inflator **70**.

The operation of this invention with a hybrid module is illustrated in Fig. 6, wherein a hybrid inflator is shown generally at **90**. Where like components to those used in the passenger side inflator **16** are used the same reference number is also used. The optical fibre cable **18** conducting radiation from the laser source **12** is attached to the base plate **92** of the hybrid inflator **90** by connector **26**. The optical fibre **22** is optically coupled to the optical window **28** sealed in first aperture **94** in the base plate **92** of driver side inflator **90**. The inner surface **66** of the optical window is optically coupled to igniter **96**. Upon ignition, igniter **96** generates high temperature gases which force plug **97** out of the igniter **96**, rupturing barrier foil **98** on the outside surface **100** of the ignition chamber **102**. The hot gases are conveyed through aperture **104**, into the pressurized gas chamber **106**, heating the pressurized gas **44**. The overpressurized gas causes membrane **108** to rupture, forcing the gas to exit through exhaust apertures **110** formed in diffuser **112** of the hybrid inflator **90**.

The inflators **16**, **70**, and **90** for use with this invention can be any inflators known to those of ordinary skill in the art. Modification of the end cap **24** and base plates **72** and **92** may be necessary to accommodate the optical window **28**. In order to minimize weight, the inflators **16** and **70**, are typically composed of aluminum.

A signal from a crash sensor (not shown) is processed by the DERM **10** the output from which is provided by the laser source **12** through optical fibre cable **18**. The radiation passing through the optical fibre cable **18** passes through optical window **26** and initiates the burning of igniter **14**. The igniter **14** initiates burning of the gas generating material **44**. The gas produced exits the inflator **16** and flows into the air bag cushion from the inflator **16** through the air bag cushion gas inlet. The expanding air bag cushion ruptures the tearseam of the module cover, or opens the hinged cover, and starts to deploy into the vehicle passenger compartment. Absent the input from the laser source **12** to the igniter **14** the inflator **16** will not initiate gas generation under normal storage and op-

erating conditions due to the absence of any components capable of processing radio-frequency energy or static electricity into heat energy.

Thus, in accordance with the invention, there has been provided a means to eliminate the potential of accidental ignition of an automotive air bag inflator due to the effect of radar and other sources of extraneous radio-frequency on an unshielded or ungrounded squib. There has also been provided a means to eliminate the potential of accidental ignition of an automotive air bag inflator due to the effect of the build-up of electrostatic energy on an unshielded or ungrounded squib. Additionally, there has been provided a simplified ignition chain for initiating the gas generating process within an air bag inflator.

Claims

1. An apparatus for igniting a gas generator for use in motor vehicles by radiant energy supplied from a laser (12) comprising:

   an optical fibre (18) for conducting radiant energy from said laser;

   a gas generator housing (16) comprising a chamber having at least one open end;

   a means (24) for closing said open end thereby defining at least one sealed chamber, said closing means having an external surface, an internal surface (56) and an aperture (30) generally in a central region thereof;

   an optical window (28) having a first surface and a second surface (66), said optical window being sealed within said aperture (30) with said first surface in optical contact with said optical fibre;

   a propellant initiating means (14) in said sealed chamber in optical contact with said second surface (66) of said optical window;

   a pressurised gas, or a gas generating material (44) arranged to generate a gas under pressure, within said sealed chamber adjacent to said propellant initiating means; and one or more apertures (50) in said sealed chamber for directing generated gas from said combustion chamber to a vehicle inflatable restraint cushion.

2. An apparatus according to claim 1 wherein said housing (16) is an elongated cylindrical housing and encloses a tubular combustion chamber containing a gas-generating material (44).

3. An apparatus according to claim 1 wherein said housing is a disk-shaped circular housing (70) including a circular combustion chamber (84) having at least one open end portion, and means (72) for closing said open end portion thereby defining at least one combustion chamber for a gas generating material.

4. An apparatus according to claim 1 or claim 2 wherein said propellant initiating means includes a linear deflagration cord (32) having a first end (52) and a second end.

5. An apparatus according to claim 4 further comprising:

   a collet member (54) having an aperture (52) in a central region thereof into which said first end of said linear deflagration cord (32) is inserted and attached; and

   a support member (58) having a first surface (62) and a second surface, said second surface of said support member being in spaced relationship to said internal surface (56) of said closing means (24);

   wherein said first surface of said support member supports said collet member (54) thereby holding said first end of said linear deflagration cord (32) in optical contact with said second surface (66) of said optical window (28).

6. An apparatus according to claim 5 further comprising a spring (60) between said collet member (54) and said first surface (62) of said support member (58) thereby bringing said first end (52) of said linear deflagration cord (32) into contact with said second surface (66) of said optical window (28).

7. An apparatus for igniting a gas generator for use in motor vehicles by radiant energy supplied from a laser comprising:

   an optical fibre (18) for conducting radiant energy from said laser (12);

   a gas generator housing (90) comprising a chamber (106) having at least one open end;

   a means (92) for closing said open end thereby defining at least one sealed chamber, said closing means having an external surface, an internal surface, and an aperture (94) generally in a central region thereof;

   an optical window (28) having a first surface and a second surface, said optical window being sealed within said aperture, said first surface of said optical window being in optical contact with said optical fibre (18);

   a propellant initiating means (96,102) in said sealed chamber in optical contact with said second surface of said optical window;

   a pressurised gas within said sealed chamber adjacent to said propellant initiating means; and

   one or more apertures in said sealed chamber for directing generated gas from said chamber to a vehicle inflatable restraint cushion.

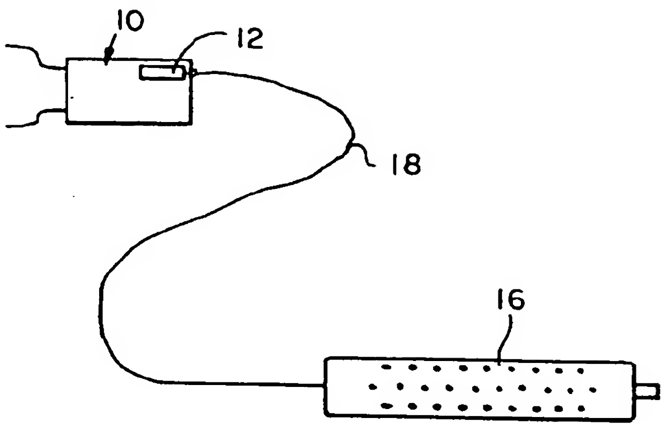
10
12
18
16

FIG. 1

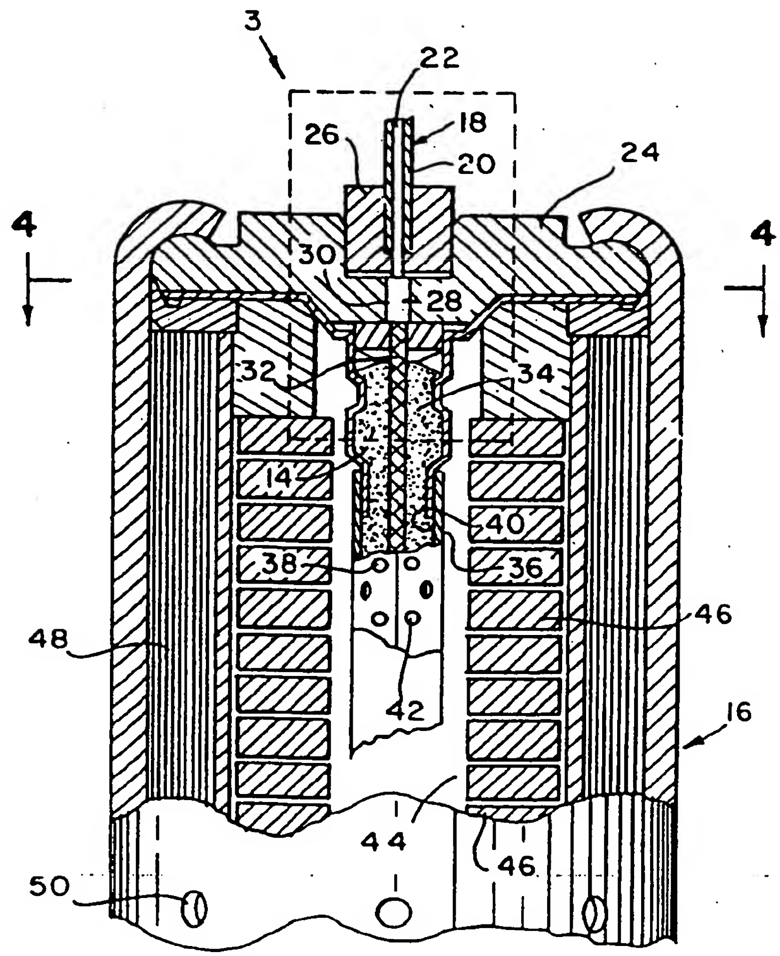
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FIG. 2

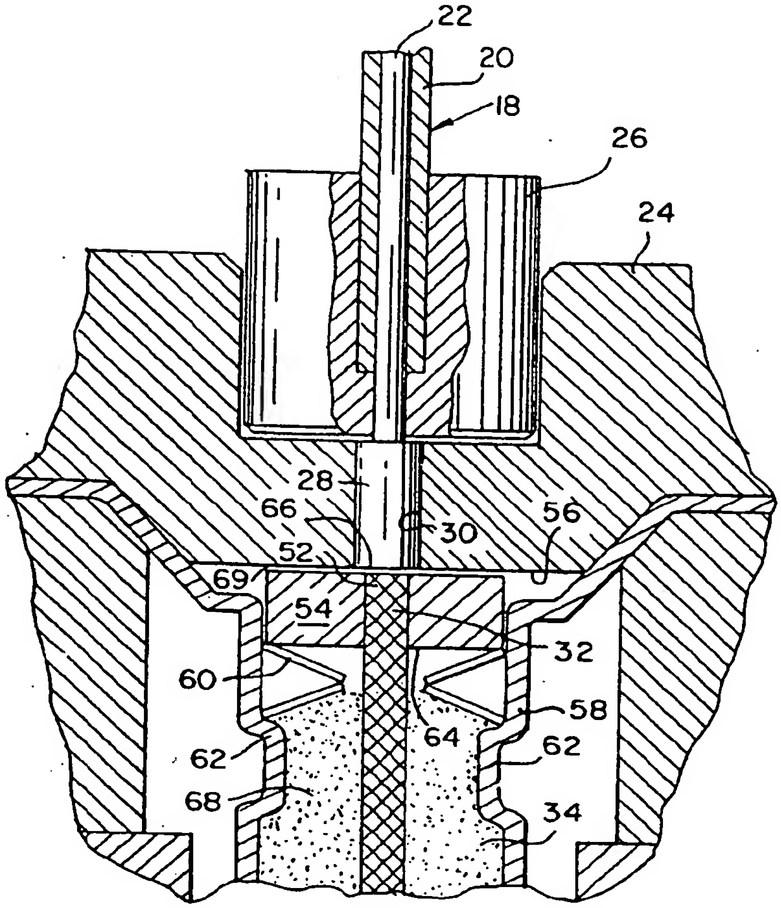
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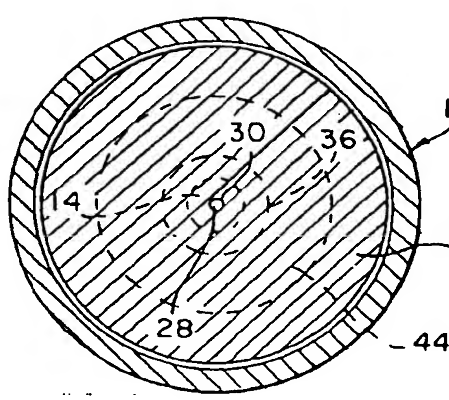
FIG. 3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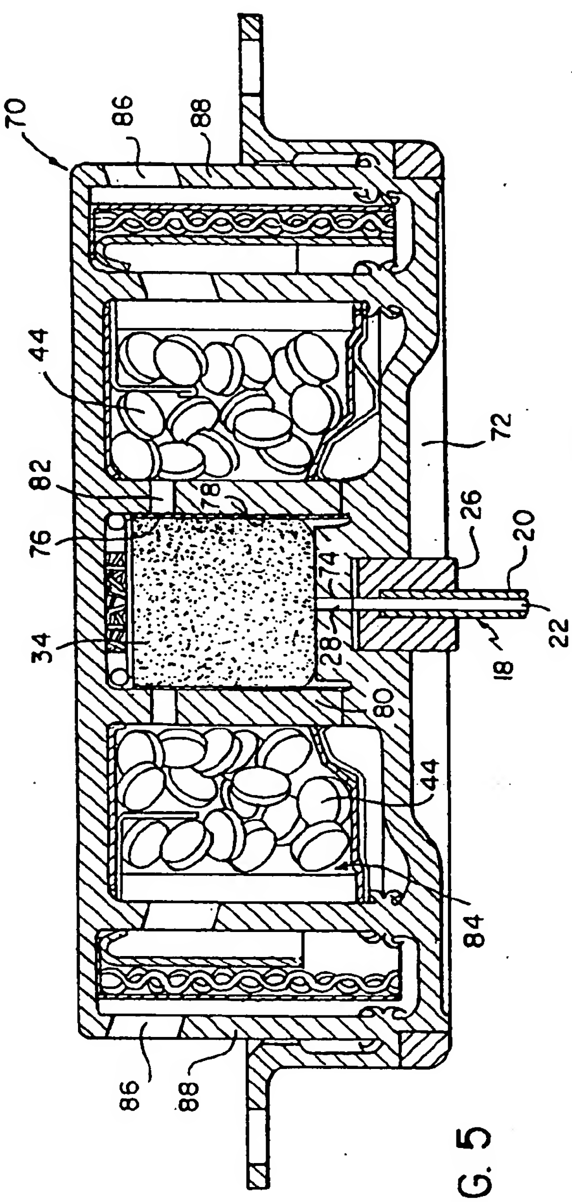
14
24
28
44

FIG. 4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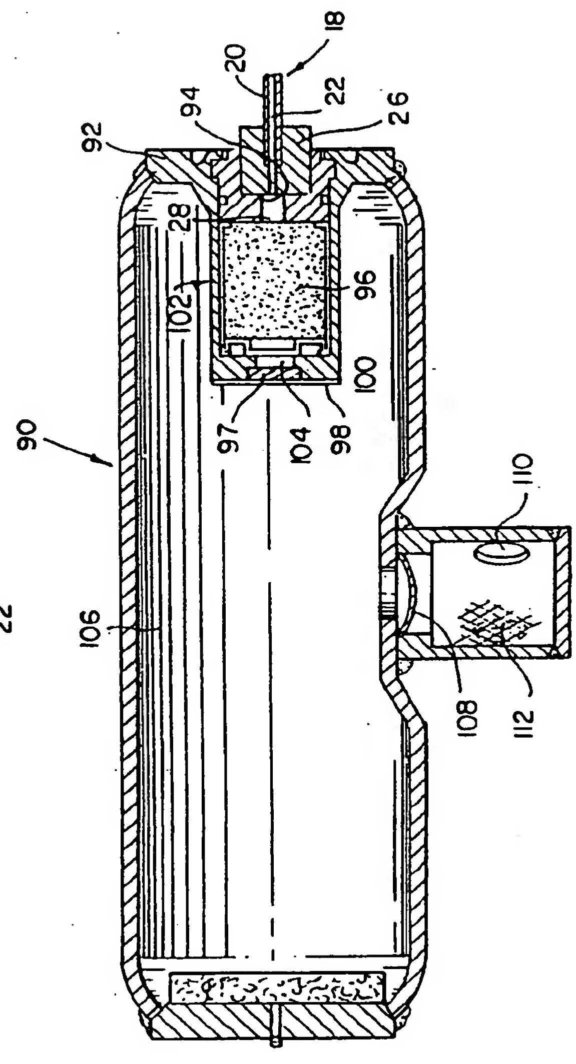
18
80
84

FIG. 5


18
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26
94
92
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102
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104
98
90
106
110
108
112

FIG. 6